DEVELOPMENT OF AUTO RE-CLOSER EARTH LEAKAGE CIRCUIT BREAKER (AR-ELCB)

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ABSTRACT

An Earth Leakage Circuit Breaker (ELCB) is an electrical device that disconnects protected circuit whenever it detects unbalance current between the phase conductor and the neutral conductor. Such an unbalance is sometimes caused by current leakage through the body of a person who is grounded when accidentally touching the energized part of the circuit. A lethal shock can result from these conditions. ELCB are designed to disconnect this fault fast enough to mitigate the harm caused by such shocks. Currently, there is no Earth Leakage Circuit Breaker (ELCB) with auto re-closer features in the market. The current ELCB that available in the market is a manual type and cannot differentiate between temporary disturbances and permanent faults. It's means that, if a disturbance or fault occurs on the protected area (house or shop), the protection system will force ELCB to trip. One of the drawbacks of the common ELCB is that, it's can't turn on the power supply back to the normal operation condition although only a short disturbance occurs. Such disturbance is lightning strike on the transmission line in the distribution site near to the protected area. To turn the power back to normal operation, consumers need to do that manually. To overcome this problem, Auto Re-closer Earth Leakage Circuit Breaker (AR-ELCB) has been developed. This thesis presents the development of AR-ELCB. This device was designed to differentiate between permanent fault and short disturbances (lightning).

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CHAPTER 1

INTRODUCTION

1.1 Project Background

The project is based on the problems of today ELCB that is controlled manually and cannot differentiate between permanent and temporary fault. This sometimes bring the problems to the consumer who were not at home and do not understand the danger of permanent fault that can cause fatal hazard.

This project is focused on the design and building a unit of auto re-closer earth leakage circuit breaker (ELCB) that can differentiate and act differently with different type of fault. The concept is if there are faulty occurred, the ELCB will trip, if the fault is from temporary fault type like lightning, ELCB will close back automatically after three seconds. But if the faulty is eternal/permanent fault like from electrical, electronic device or short circuit ELCB will eternally trip and the permanent faulty lamp/buzzer will on until the fault root cause is removed and the switch is “on” back by someone again. In this project the microcontroller processor has been chosen as a control element.

Firstly, the problem in this project is to understand and know what kind of differentiation between permanent fault and temporary fault. All aspect must be considered and there must be no neglecting even a little reason to gain the good result. And surely is to think how to trace the faulty with new device and combined it with other devices like control element and old ELCB to get the new Auto re-closer circuit

breaker. In this combination, all power and source value of voltage and currents of each device must be considered, and for that reason the designing of the additional circuit is important to match the voltage and currents value so that it is suitable with control element and the devices could work together.

1.2 Objectives:

The objectives of this project are:

i. To improve the ability of earth leakage circuit breaker (ELCB) unit
ii. To notify the type of fault whether temporary or eternal/permanent fault.
iii. To develop the Auto-Re closer ELCB

1.3 Scope of project

i. This project is focused to modify and improve the ELCB where the additional circuit with a system is added to the ELCB and automatically will make ELCB trigger/open when the permanent fault occurred and auto re-closed when temporary fault happened.
ii. To make the circuit more accurate and better, the microcontroller is used as a control element and the model is MC68HC11AI MOTOROLA Microprocessor.

1.4 Literature Review

ELCB is the **E**arth **L**eakage **C**ircuit **B**reaker. There are two types of ELCBs, the voltage operated device and the differential current operated device vELCB and iELCB. vELCBs were first introduced about sixty years ago and iELCB were first introduced about forty years ago.

The principle of operation of the vELCB is as follows. Under normal conditions the closed contacts of the vELCB feed the supply current to the load. The load is protected by a metal frame, such as in an electric cooker. The vELCB also has a relay coil, one end of which is connected to the metal frame and one end connected directly to ground. A shock risk will arise if a breakdown in the insulation occurs in the load which causes the metal frame to rise to a voltage above earth. A resultant current will flow from the metalwork through the relay coil to earth and when the frame voltage reaches a dangerous level, e.g. 50 volts, the current flowing through the relay coil will be sufficient to activate the relay thereby causing opening of the supply contacts and removal of the shock risk.

ELCB is essentially a voltage sensing device intended to detect dangerous voltage and current fault. The level of shock protection provided by the vELCB was somewhat limited as these devices would not provide shock protection in the event of direct contact with a live part. An additional problem with the vELCB was its tendency to be tripped by earth currents originating in other installations.

For many years, the voltage operated ELCB and the differential current operated ELCB were both referred to as ELCBs because it was a simpler name to remember. However, the use of a common name for two different devices gave rise to considerable confusion in the electrical industry. If the wrong type was used on an installation, the level of protection given could be substantially less than that intended. To remove this confusion, IEC decided to apply the term Residual Current Device (RCD) to differential

current operated ELCBs. Residual current refers to any current over and above the load current.

Through early research that have been done and the guidelines from articles, it states that the development of ELCB is focused to only development of better device and not to improve the system of ELCB cause there are no articles that give the idea how to add the function and system to this ELCB. Until today what the article said is the type, function and process of each component in ELCB. So it is important to struggle and combine all knowledge to design something new for this device.

1.5 Thesis Outline

This thesis contains 5 chapter which is every chapter have its own purpose. After viewing the entire chapter in this thesis hopefully viewer can understand the whole system design for this project.

Chapter 1 describe on the background of the project, objectives, scope of the project and the literature review that referred to in the development of Auto Re-Closer Earth Leakage Circuit Breaker (AR-ELCB).

Chapter 2 is focused to the theory of the Earth Leakage Circuit Breaker (ELCB), where it described about problems, ELCB design, the components inside ELCB and the operation of this device.

Chapter 3 elaborated more on the designing and operation of the new AR-ELCB systems. Besides it also describe the functions of each components used in the circuit especially on the second stage circuit.

Chapter 4 only focused to the control element circuit which is the most important part of the system. It described about the system of microcontroller detailed from the hardware until the software that has been used in this project.

Chapter 5 presents the data and result that have been got from the experiments while in development process. The result of this project also is accompanied by the discussions for each problem statements.

Lastly is chapter 6, in this chapter the conclusion have been made for the project from the whole aspect and there are also suggestions to improve the AR-ELCB on the future, it is for the commercialization. There is also the costing stated to produce the AR-ELCB.

CHAPTER 2

EARTH LEAKAGE CIRCUIT BREAKER

2.1 Introduction

An Earth Leakage Circuit Breaker (ELCB) is a device used to directly detect currents leaking to earth from an installation and cut the power. It was mainly used in TT earthing systems. The device could detect the leakage current and protect consumer from electrical shock if leakage current occurred to the consumer equipments. This device will cut off the electrical supply instantaneously when current leakage is detected. There are two types of ELCB:

i. Voltage Earth Leakage Circuit Breaker (vELCB)
ii. Current Earth Leakage Current Earth Leakage Circuit Breaker (iELCB)

This chapter describe about nowadays earth leakage circuit breaker that used in 240Vac for home and offices user. Before begin any project, whether to make any development or upgrading at least, it is important to understand the basic of the equipment and know how the device works. To achieve the objective for this chapter, the research of Earth Leakage Circuit Breaker is done by exploring the 240Vac ELCB that normally used for home or offices.

The objectives of this chapter are:

i. To know the system of basic Earth Leakage Circuit Breaker
ii. To know the components of Earth Leakage Circuit Breaker and know the function of each component.
iii. To understand how the device work

2.2 vELCB

vELCB is a voltage operated circuit breaker, the device will function when the Current passes through the ELCB. vELCB contains relay loop which it being connected to the metallic load body at one end and it is connected to ground wire at the other end. If the voltage of the load body is rise which could cause the difference between earth and load body voltage, the danger of electric shock will occur. This voltage difference will produce an electric current from the load metallic body passes the relay loop and to earth. When voltage on the load metallic body raised to the danger level which exceed to 50Volt, the flowing current through relay loop could move the relay contact by disconnecting the supply current to avoid from any danger electric shock.

2.3 iELCB

iELCB is current operated circuit breaker. The device will function with when the Current passes through ELCB. This current admitted to current transform device and on the load. Current from the load also admitted again to transform device. In normal state, total current applied to load is equal with total current out of the load. Because of the balance of in and out of current, it does not affect the current transform device. If there is any earth current leakage caused by earth damage, then the in and out current

will no longer in balance. These unbalance current phenomena will generate the current and if the current exceeded the prescribed rate, the ELCB will jerked and cut off the supply. The device also is called RCD, residual current device in IEC or RCCB residual current circuit breaker.

2.4 Problems of ELCB or RCCB

Earth Leakage Circuit Breaker is one type of electrical equipment that used as a protection device. The main purpose of this type of equipment is to cut off the power when the problem occurred. But the problem is will the device back to normally condition and function if the error occurred and there are no a human that can switch on back the device due to many reasons.

The device is using mechanical switch that must be switch on manually, after ELCB is being tripped it will stay off until there is someone push it back to the on condition although the problem that occurred is temporary fault and occurred in one millisecond.

The device also can not differentiate whether the fault is temporary or permanent fault where there are the differentiations between these two types. It also do not act differently for these two types of faulty.

2.5 Electrical faults

A fault is any abnormal situation in an electrical system in which the electrical current may or may not flow through the intended parts. Equipment failure also attributable to some defect in the circuit, example are loose connection, insulation failure or short circuit etc. Types of faults in a distribution network circuit are:

i) Over-load
ii) Faults on electrical equipments
iii) Transmission lines faults

Over-load faults are caused by the unexpected increasing of loads. Faults on electrical equipments are caused by lightning, insulator breakage, Product design which is out of specification and Improper installations of equipments.

Most faults on transmission lines of 100kV and higher are caused by lightning, which results in the flash over of insulators. Transmission lines faults are caused by, lightning, storm, fallen trees, Snow. One of the temporary faulty is cause by direst lightning phenomena. Where example of permanent fault is faults on electrical equipment.

2.6 ELCB Features

Figure 2.1 shows about Home ELCB with the housing, the function of this housing as the protection for the circuit. What who can be seen from this condition is only mechanical switch and the black box.

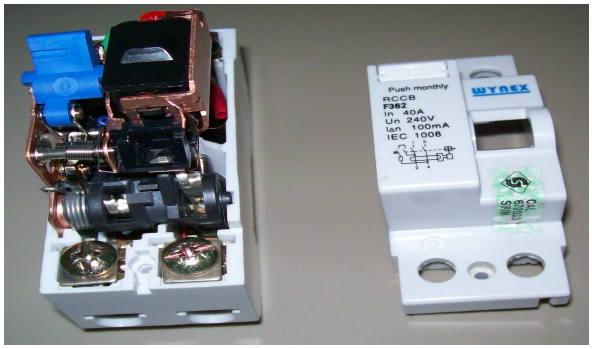

Figure 2.1: Home ELCB/RCCB with housing.

Figure 2.2 shows the whole ELCB component inside the housing, the most important thing in the system is the good insulator must be used for live and neutral cable, it is to avoid from ELCB self fault.

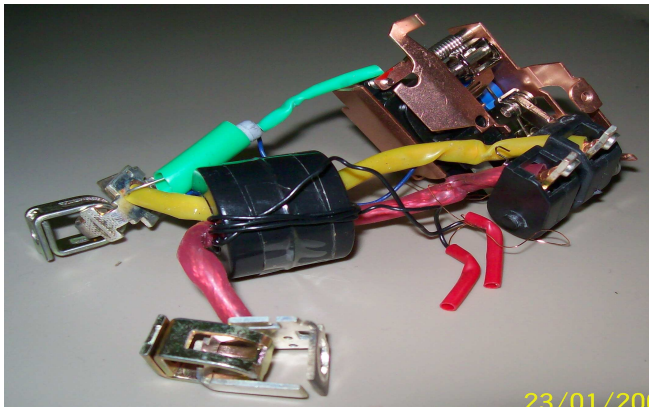

Figure 2.2: The system inside ELCB

2.7 ELCB Design

Figure 2.3 shows the design of ELCB, the design consists of mechanical switch, ZCT, Black Box, High level transistor and the reset button. Mechanical switch is a contact of black box, the function of this component is to trigger and cut off the power with cut off the life and neutral line altogether. The function of high level transistor is to limit the current flowing through its line when the reset button is pushed. Then the ZCT, the function of this component is to detect the unbalance current in the system and send the signal (induced current) to Black Box. In a black box there is a coil, the coil will activate the mechanical switch after received the minimum current level 100mA (theoretically) from the ZCT. Lastly, there is also reset button, the function of the reset button is to re-set back the device to the initial condition and also as a point to detect whether the device still in good condition or damage/expired.

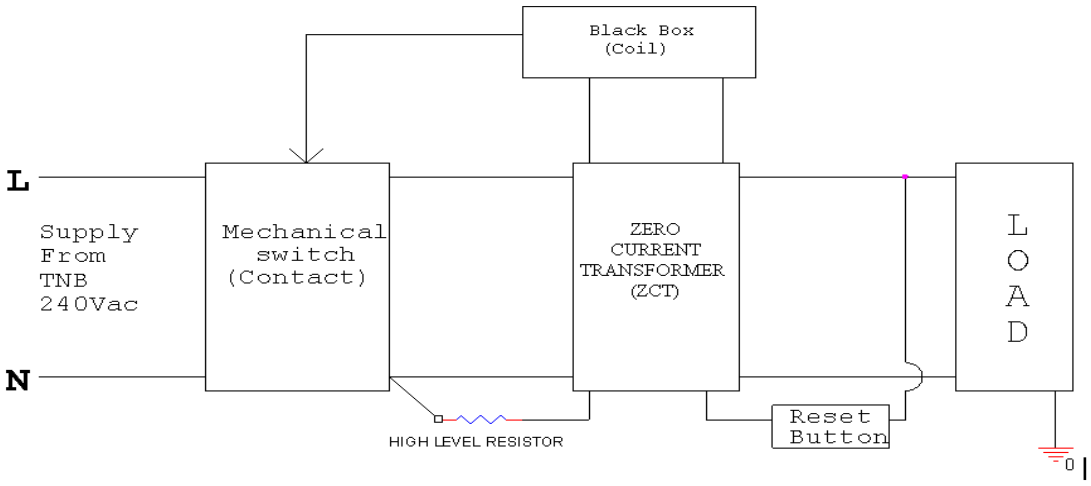

Figure 2.3: Earth Leakage Circuit Breaker design

2.8 Operation of ELCB

Based on the Figure 2.4 when the faulty occurred, ZCT will detect the imbalance current in the system, so the induced current will happened in ZCT, induced current that reached the min value to activate the coil will be send as a signal to the Black Box, when the coil is activated, it will sense the contact to trigger and automatically the mechanical switch is triggered and this will cut off the supply from main line.

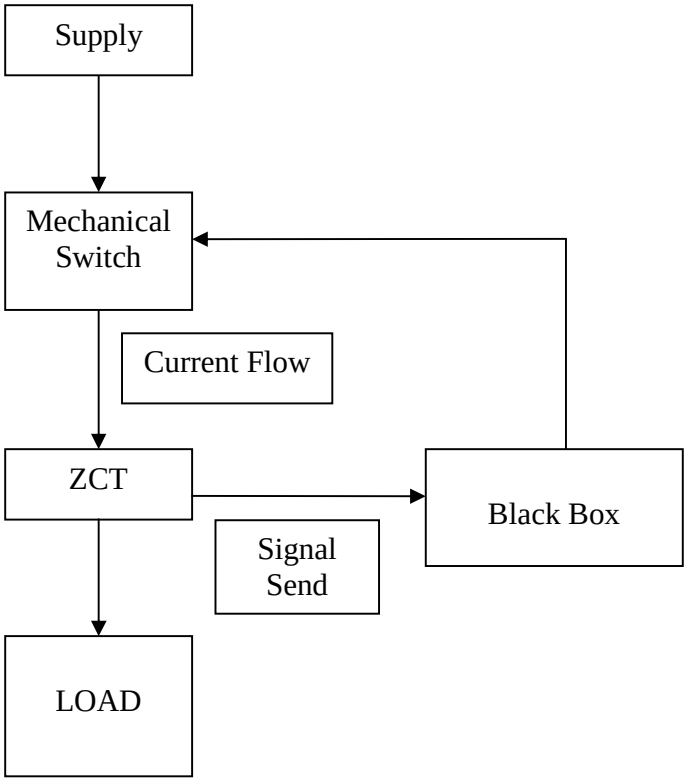

Figure 2.4: Earth Leakage Circuit Breaker Operation Flow

2.9 Summary

There are two types of ELCB, both device used for protection device for electrical equipment and for safety for human being from fatality hazard. Each device has a little differentiation in operation. If there are the faulty occurred the device will with cut off the supply in the main line. So the equipment will be safe. ELCB also must be able to act differently between permanent fault and temporary fault. It can improve ELCB ability and can its function. From this study, it helps to understand the principles, operation, and function of each device.

CHAPTER 3

DEVELOPMENT OF AUTO RE-CLOSER EARTH LEAKAGE CIRCUIT BREAKER

3.1 Introduction

This chapter explained about the methodology and technical aspect that used in the development of the AR-ELCB from the project flow, circuit design until the device chosen. Beside of it also describes about final hardware design of auto re-closer circuit breaker, the reason, advantages and the function of each circuit. The effectiveness of new idea have been considered, then several efforts and changed have been done to the new circuit design in order to decrease the cost and maintain the function of the product.

3.2 Project Flow

This project is began with study the problem of old device, this is done by took at look at the physical and consumer problem. The next stage is identified the element that can be improved due to the budget and knowledge for this type of device. After that, studied the operation of old device and knew all functions of each component inside ELCB and understand how the devices work. Next is proposed the idea to improve the device altogether with problem solving. The next stage is implement the knowledge and make development to the project, it includes designing process for the new device, install the control element circuit(Microcontroller), design the programming software of microcontroller and program it into Microcontroller IC. After finish in control element part, installation of the IC linear voltage regulator circuit, current transducer circuit has been done. Lastly is all circuit was combined with ELCB. Then the new Auto Re-closer ELCB was tested in laboratory, there were several problems occur, the hardware has been troubleshooting, and the retest process was done again until the hardware fully functions and the objectives of this project achieved.

3.3 AR-ELCB Design

From the Figure 3.1, the Heavy Duty Power Relay replaced the function of mechanical switch in old ELCB. Function of Zero Current Transformer (ZCT) is to detect the unbalanced current between life and neutral line. Function of 240/15 Vac Transformer is to reduced the voltage and supply to IC linear Voltage Regulator. As an early protection at control supply line, the zener diode was used to ground the over voltage instantly if over voltage occurred in this line.

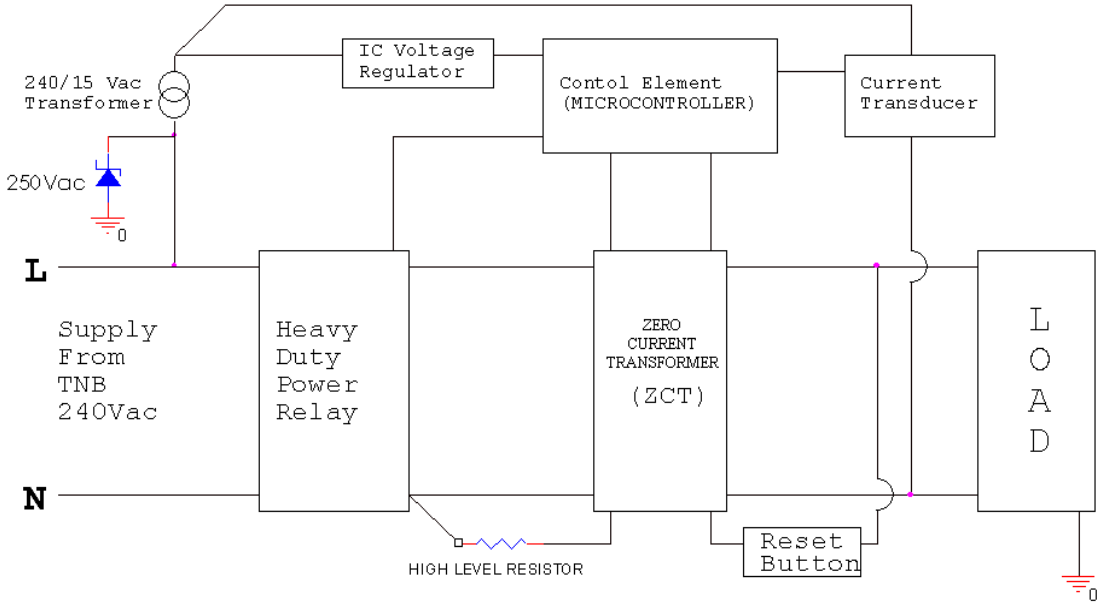

Figure 3.1: Proposed design of Auto Re-closer Circuit Breaker

For IC Voltage Regulator, the model of LM7805 was used to fix the voltage from 15V of Transformer to 5V for control element circuit. The function of current transducer is to detect the range of current in neutral line and send the signal to the microcontroller.

3.4 Improvement and Hardware Design

Refer to the Figure 3.2 it shows the block diagram for the whole system of AR-ELCB. Heavy Duty Power Relay replaced the function of mechanical switch in old ELCB. Function of Zero Current Transformer (ZCT) is to detect the unbalanced current between life and neutral line. Function of 240/15 Vac Transformer is to reduced the voltage and supply to power supply circuit. As an early protection at control supply line, the zener diode was used, the device is used to ground the over voltage to earth instantly if over voltage occurred in this line.

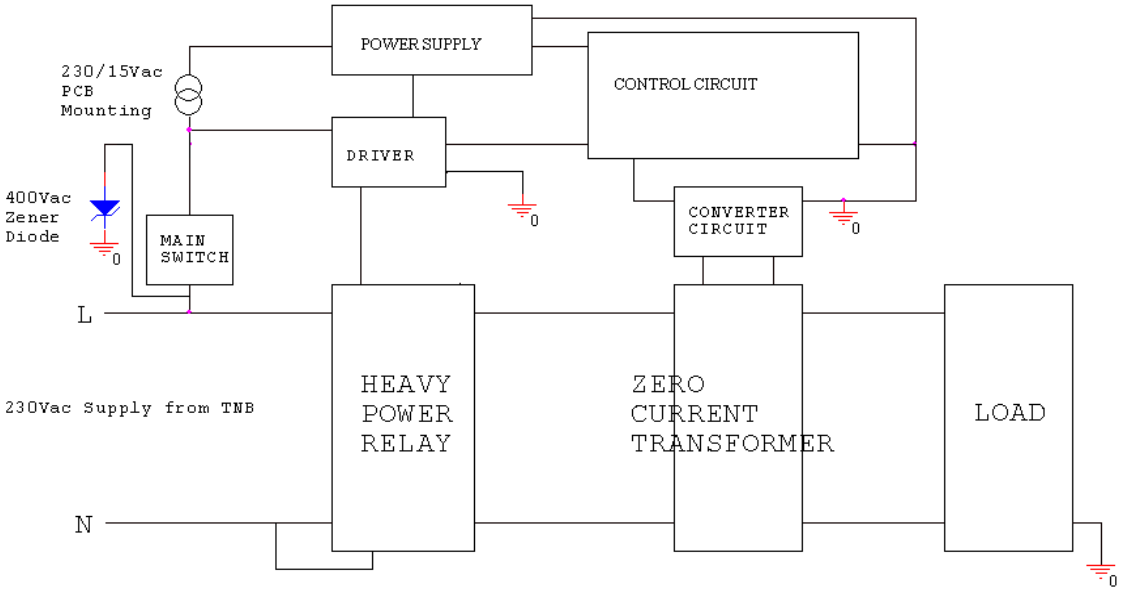

Figure 3.2: Final Design of Auto Re-Closer ELCB

The model of IC used is Motorola MC68HC11A1 it will function as a brain of the control element circuit. Then the IC Voltage Regulator circuit is used for power supply circuit. The Main switch is 250Vac switch. Driver also is used for intermediary between Heavy Power Relay with microcontroller and with main power supply, and then the TRD-5VDC-FB-CL has been chosen for the driver.

Lastly is the converter circuit, the converter circuit will convert the current from Zero Current Transformers (ZCT) to voltage and the voltage will be sent to switch circuit and the Op-Amp has been chosen as the main device.

3.5 Stage 1 Circuit

Refer to the Figure 3.3 it is control element circuit bootstrap mode, this circuit is the combination from one MC68HC11A1 MOTOROLA microprocessor that act as the brain of the system, there is also MAXIM 233, the function of MAXIM or MAX233 is to interface the computer with microprocessor. DPST switch, function as reset button in this circuit, there is also 8MHz crystal used to control the clock cycle of the system. The LM7805 was used for voltage regulator circuit, it is to produce $5V_{dc}$ output to supply the power to microcontroller circuit. There are also one 10MΩ, four 4.7kΩ resistors, two for each 4.7uF, 1uF, and 22pF capacitors. The detailed is described in Chapter 4.

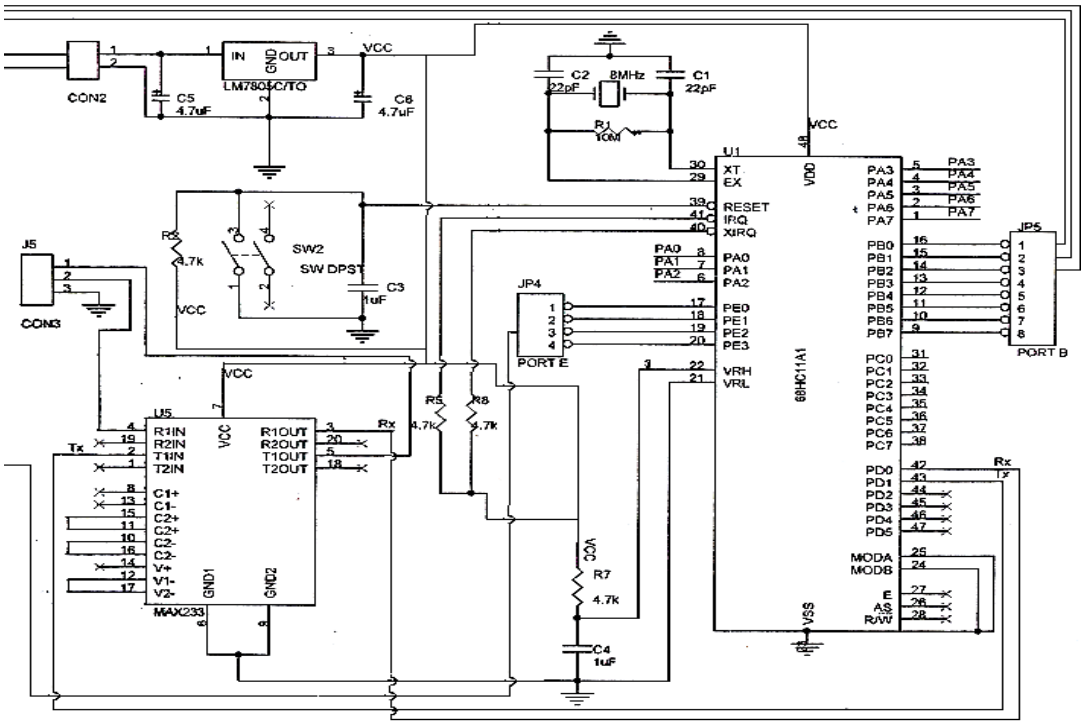

Figure 3.3: Bootstrap Mode Circuit